PATENT ABSTRACTS OF JAPAN

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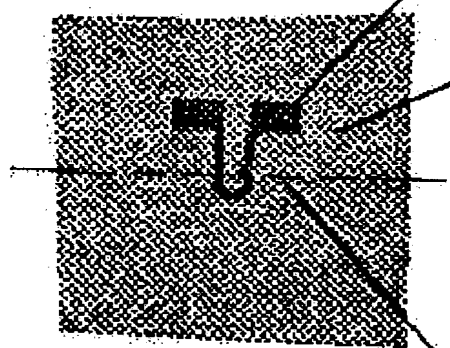
(54) MICROCHEMICAL ANALYTIC SYSTEM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an element technique of a new microplasma source or micronebulizer allowing a high sensitivity or microanalysis, and a microchemical analytic system equipped therewith on a chip.
SOLUTION: In this microchemical analytic system comprising a fine passage arranged on a substrate to constitute a flow type analytic system, a VHF-driven inductively coupled microplasma source part is arranged in the passage.



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CLAIMS

[Claim(s)]
[Claim 1] The micro chemical-analysis system characterized by arranging the source section of VHF drive micro inductively coupled plasma in passage in the micro chemical-analysis system by which detailed passage is arranged by the substrate and the flow mold analysis system is constituted.
[Claim 2] The micro chemical-analysis system of claim 1 characterized by arranging the micro antenna on a substrate at the source section of the plasma.
[Claim 3] It is the micro chemical-analysis system characterized by making free mount/dismount of the source of VHF drive micro inductively coupled plasma to a substrate in the micro chemical-analysis system of claims 1 or 2 as a module.
[Claim 4] The micro chemical-analysis system characterized by forming the micro nebulizer section in passage in the micro chemical-analysis system by which detailed passage is arranged by the substrate and the flow mold analysis system is constituted.
[Claim 5] The micro nebulizer section is the micro chemical-analysis system of claim 4 characterized by the capillary tube for installation of carrier gas being arranged at the flank of one of the two of the capillary tube of the center section which introduces a minute amount liquid sample, or both, and making it carrier gas blow off from the tip flank of a center-section capillary tube.
[Claim 6] It is the micro chemical-analysis system characterized by making mount/dismount of the micro nebulizer section free to a substrate in the chemical-analysis system of claims 4 or 5 as a module.
[Claim 7] The micro chemical-analysis system characterized by approaching the nebulizer section and arranging the source section of VHF drive micro inductively coupled plasma in passage in claim 4 thru/or one micro chemical-analysis system of 6.
[Claim 8] The micro chemical-analysis system characterized by making possible inductively coupled plasma-atomic emisson spectroscopy in claim 1 thru/or one micro chemical-analysis system of 7.
[Claim 9] The micro chemical-analysis system characterized by preparing the micro capillary-electrophoresis section in claim 1 thru/or one micro chemical-analysis system of 7.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This application invention relates to a micro chemical-analysis system (muTAS:Micro Total Analysis Ststem). It is related with a still more detailed micro chemical-analysis system new [for minute amount matter detection / high sensitivity invention / of this application], and the component engineering for it.
[0002]
[The technical problem of a Prior art and invention] Invention of this application forms the flow mold analysis system which carries out micro processing of the slot of several 10-micrometer width of face, and performs high-speed separation of ultralow volume matter, such as a gas chromatography (GC) and micro capillary electrophoresis (muCE), on chips, such as silicon, glass, and plastics. Research of the micro chemical-analysis system (muTAS:Micro Total Analysis System) which realizes high performance analysis more innovative than combination with the on-chip high sensitivity detection approaches, such as laser-induced-fluorescence detection and electrochemistry measurement by microelectrode, is progressing quickly. Application in a large field, such as a gene analysis, a medical inspection, and new drug development, is expected.
[0003] moreover, the high speed and ultra high-speed which combined the inductively coupled plasma-atomic emisson spectroscopy (ICP-OES:Inductively Coupled Plasma Optical Emission Spcciroscopy) known for the bench top's analysis apparatus by separation technology, such as capillary electrophoresis, as an elemental-analysis method sensibility is very high, and ICP mass analysis -- the sensibility matter detection approach is developed in recent years.
[0004] Then, although it is possible to make a high density microplasma generate on chips, such as glass, to pile up muTAS, and to apply as a high sensitivity detection module, about generation of the high density microplasma on a chip, and the application to muTAS chip, the actual condition is not realized the place which is the former.
[0005] The report of the beginning of the microplasma chip for analysis is released in 1999 for the purpose of the atom in GC (gas chromatography) which turned muTAS by A.Manz and others, and molecule detection. In minute space with a width-of-face [of 450micro] x depth [of 200 micrometers] x die length of 2000 micrometers formed in the glass chip, the direct-current glow discharge of helium was generated with 10-50mW power under reduced pressure of about 17 kPa(s), and 600 ppm of limit of detection of methane are estimated. Although it became discharge impossible by the spatter of a cathode electrode in 2 hours, with atmospheric pressure, it is reported after that by the actuation under reduced pressure that actuation of 24 hours is also possible.
[0006] Moreover, the 2.45GHz microwave discharge chip using a microstrip antenna is reported as first microplasma chip which operates with an atmospheric pressure and a non-electrode, the discharge interior of a room with a depth [of 0.9mm] x width-of-face [of 1mm] x die length of 90mm is made to generate discharge with a die length of 2-3cm in 10-40W, and 10 ng(s)/ml is reported as limit of detection of mercury vapour.
[0007] However, the thing that the high sensitivity microanalysis by implementation of the microplasma to muTAS chip is made possible is not still realized. It is because it is not easy to generate the stable high density plasma in minute space with small power.
[0008] And although it becomes that to which a micro nebulizer is indispensable in order to make the liquid sample of a minute amount applicable to analysis, although such implementation of the source of a microplasma must be accumulated on a chip as a micro chemical-analysis system again and a flow mold analysis system must be constituted, there is a problem that it is not practical about such a means.
[0009] Then, invention of this application makes it the technical problem to offer the micro chemical-analysis system which equipped the chip with this with a component engineering called the new source of a microplasma and micro nebulizer which cancel the trouble as above and make a high sensitivity microanalysis possible.
[0010]
[Means for Solving the Problem] Invention of this application provides the 1st with the micro chemical-analysis system characterized by arranging the source section of VHF drive micro inductively coupled plasma in passage as what solves the above-mentioned technical problem in the micro chemical-analysis system by which detailed passage is arranged by the substrate and the flow mold analysis system is constituted.
[0011] Moreover, the above-mentioned source section of the plasma is provided with the micro chemical-analysis system characterized by making free mount/dismount of the source of VHF drive micro inductively coupled plasma to a substrate the 3rd as a module in the micro chemical-analysis system characterized by arranging the micro antenna on a substrate the 2nd.
[0012] In the micro chemical-analysis system by which passage detailed to a substrate is arranged in the 4th, and the flow mold analysis system is constituted by invention of this application The micro chemical-analysis system characterized by forming the micro nebulizer section in passage is offered. To the 5th The capillary tube for installation of carrier gas is arranged at the flank of the capillary tube of the center section where the micro nebulizer section introduces a minute amount liquid sample. The micro chemical-analysis system characterized by making it carrier gas blow off from the tip flank of a center-section capillary tube to the 6th Invention of this application that offers the micro chemical-analysis system characterized by making mount/dismount of the micro nebulizer section free to a substrate as a module The 7th is provided with the micro chemical-analysis system characterized by approaching the above-mentioned nebulizer section and arranging the source section of VHF drive micro inductively coupled plasma in passage. To the 8th The micro chemical-analysis system characterized by making possible inductively coupled plasma-atomic emisson spectroscopy is offered, and the 9th is provided with the micro chemical-analysis system characterized by preparing the micro capillary-electrophoresis section.
[0013]

[Embodiment of the Invention] Although invention of this application has the description as above-mentioned, it explains the gestalt of that operation below.
[0014] The source section of the micro VHF plasma first incorporable into muTAS is explained.
[0015] It is necessary to generate the plasma with sufficient excitation efficiency by high density in the source of the plasma included in muTAS in the minute discharge tube which does not have a DETTO tooth space so that separability, such as GC, may not be spoiled. The physical quantity by which the plasma production in such minute space is characterized is the ratio of the characteristic length of a small discharge container, and the surface area to the discharge volume large so. For example, supposing generating helium PUZUMA of millimeter size, order estimates relation with the physical quantity, pressure, and frequency by which the plasma is characterized, it is not rich, and the pressure of about 100Pa or more is needed for setting an electronic mean free path to 1mm or less. However, since electronic energy will fall if a pressure is raised too much, a high-voltage drive is needed. The power which an electron receives in RF electric field becomes max when the electronic collision frequency nu and the power-source angular frequency omega (=2pif) are in agreement, but when electron temperature is 3cV(s), for example, the electronic collision frequency in 100-1000Pa is set to 1-10GHz, and if VHF and UHF whose power line period f is 100MHz - 1GHz are used, discharge will become possible with low power. And the further advantage using HF is in control of loss with a wall. If the collision with a neutral kind is taken into consideration, as for the amplitude of about 10 micrometers or less and an electron, in the amplitude of helium ion in the inside of the RF electric field whose amplitude of field strength is 100v/mm, a pressure will become about 1mm by 1000Pa but 10mm or more on the frequency of 100MHz at 100Pa. That is, if VHF is used by the pressure of 1000Pa or more, some of ion and electrons can be caught in the discharge tube.
[0016] Based on the above thing, the source of a microplasma by VHF drive consists of invention of this application. And as a method which combines VHF power with the plasma, the inductive coupling using the dielectric field produced according to the current which flows at an antenna can generate the plasma efficiently rather than capacity coupling which accelerates an electron from ********. Then, invention of this application is taken as the source section of an inductive-coupling microplasma by VHF drive. For example, drawing 1 is the plane partial configuration photograph in which the example was shown. For example, it can consider as the microplasma chip with which it has an one-roll monotonous mold antenna (3) with a bore of 2mm produced with the discharge tube capillary tube (2) width of face and whose depth are 1-5mm, and copper plating and photolithography in the center of a chip (1) made from the quartz of 30mm angle.
[0017] Mount/dismount of such a microplasma chip can be made free as a module at muTAS chip.
[0018] For example, about the microplasma chip of drawing 1 , the aforementioned one-roll antenna is installed on the quartz chip which has a slot with width of face of 5mm, a depth [of 1mm], and a die length of 20mm, and if plasma production of the 100MHz RF is impressed and carried out, it will be checked by Mizouchi on 10 or more Torrs of pressures, and the conditions beyond power 70W that the high density pure helium plasma occurs. helium PURAZU has the description that a MABAKKU grand spectrum has few peaks and spectrum interference with a sample is suppressed.
[0019] Moreover, although the excitation temperature of helium plasma was illustrated to drawing 2 , the excitation temperature of helium computed from the luminescence peak of helium increased with power, and amounting to 7000K in 100W was checked.
[0020] Drawing 3 shows the example of the electron density of Ar which estimated width of face and the depth from Stark broadening of helium emission spectrum (Balmer series: 486nm) of the hydrogen added in the minute amount about the case of a 1mm slot, and helium plasma, and the relation of power. Rapid increase whenever it has in the 10W neighborhood takes place, and it is checked that a plasma consistency amounts to abbreviation 1013cm-3.
[0021] And drawing 4 illustrates the result of the luminescence response on the strength by the pulse injection of Ar. By the pulse injection of Ar, the rise of plasma luminescence on the strength is checked clearly. In the above, the usefulness of the source section of VHF drive micro inductively coupled plasma of this invention to plasma spectral analysis is explained.
[0022] Since the high density plasma can be generated to minute space using the miniaturized antenna formed with lithography and the structure of the source of the plasma is also suitable for chip-ization, it is a leading means as a source of the plasma accumulated on muTAS.
[0023] Moreover, the applicability of microplasma emission spectrometry also offers the micro nebulizer for atomization-izing a liquid sample and making it blow off in invention of this application, since expansion of applicability will be required of a liquid sample from now on, although it inquires from a gaseous sample first of all, such as element detection in a gas chromatography.
[0024] This micro nebulizer is illustrated as a configuration of drawing 5 . The example of this drawing 5 is the micro nebulizer made as an experiment on the quartz chip. It is checked that-izing of the slight amount liquid sample which introduced carrier gas from the capillary tube of 10 - 20ccm sink and central 10-micrometer width of face can be carried out [**********] from the capillary tube of both sides.
[0025] As shown in drawing 5 and drawing 6 , the planar micro nebulizer was made as an experiment, and the check of operation was more specifically performed. Cr mask is used for the quartz glass of 20mm angle, and the pattern of a nebulizer is formed by dry etching with a depth of 15 micrometers. Furthermore, a metal thin film electrode is formed by sputtering in an injection nozzle with a width of face of 60 micrometers. The another chip and another sticking by pressure which finally opened the sample inlet with the supersonic machine stopped lamination and minute passage. The capillary for gas installation was attached in the chip made as an experiment. The high voltage is impressed to micro capillary tube both ends, an electroendosmose style is generated, and it atomizes by the gas which blows the liquid which flowed out of capillary tube termination from both sides. First, impregnation of 20mM phosphate buffer solution (pH=9.1) which added the 0.1mM rhodamine from the liquid pool for the high sensitivity image pick-up by the fluorescence microscope in the condition of not applying electric field to a sink and a capillary tube for nebulizer gas (N2 flow rate being 4.7sccm(s)) stopped the flow of the buffer solution in the liquid exhaust nozzle with a width of face of 8 micrometers with surface tension. Next, when the high voltage of 1.6kV was applied to the capillary tube edge, the actuation which atomizes the buffer solution by outflow and nebulizer gas from an injection tip was checked. Moreover, when N2 gas was fixed and electrical-potential-difference **** fluorescence intensity was investigated, as illustrated to drawing 7 , it was also checked that it is linearity.
[0026] For example, it cannot be overemphasized that muTAS system may be constituted as mount/dismount being free for muTAS chip by using the above micro nebulizers as a micro module. Moreover, the matter as a sample can be made disengageable by the electrophoresis and GC by the micro capillary tube, and can constitute a high sensitivity detection system for this by ICP-OES, ICP mass analysis, etc.
[0027] For example, drawing 8 is drawing which illustrated the system configuration.

[0028] The aforementioned source section of the VHF drive micro inductive-coupling high density plasma and the aforementioned micro nebulizer section are carried in the chip with the micro capillary-electrophoresis section.
[0029] The sample of a minute amount is divided into a high speed in a laboratory or a laboratory, and although it is enough even if it uses existing large-sized equipment for filling the purpose of analyzing to high sensitivity, it is indispensable to enable on-site on time measurement, such as a clinical laboratory test in a bedside, impurity contamination monitoring of a production line, and the outdoors, environmental pollutant analysis at works. An analysis system is formed into an accumulation chip, and in the whole system, handy-izing and in order to make a cellular phone still more possible, the source section of a microplasma and the micro nebulizer section of this invention serve as a very important means from this.
[0030] Of course, invention of this application is not limited at all by the above instantiation. About carrying of the details, it may be various.
[0031]
[Effect of the Invention] By invention of this application, the practical new micro chemical-analysis system which equipped the chip with this with a component engineering called the new source of a microplasma and micro nebulizer which make a high sensitivity microanalysis possible can be offered as explained in detail above.

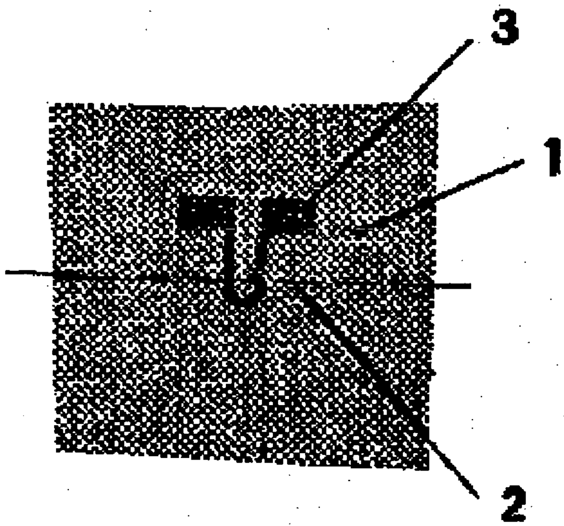
[Translation done.]

DESCRIPTION OF DRAWINGS

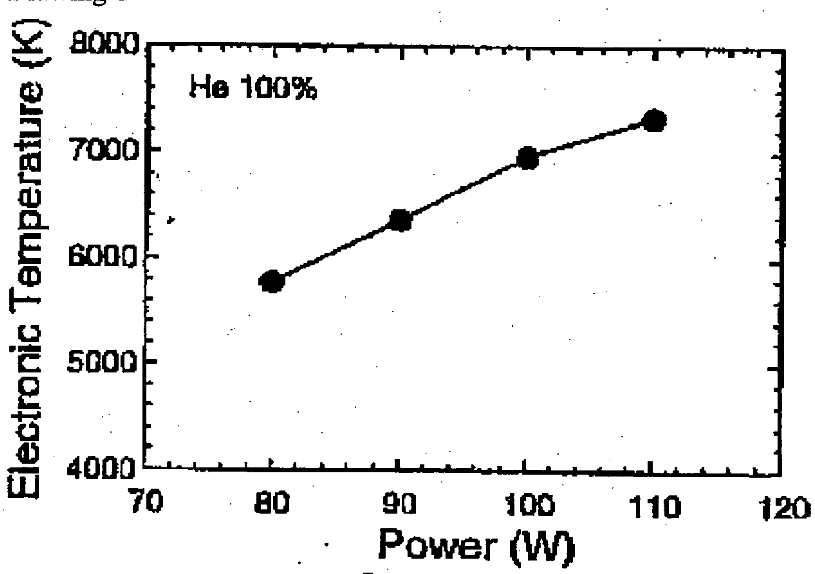
[Brief Description of the Drawings]
[Drawing 1] the microplasma chip made as an experiment was illustrated -- it is a flat-surface photograph a part.
[Drawing 2] It is drawing which illustrated the relation between helium plasma excitation temperature and electron temperature.
[Drawing 3] It is drawing which illustrated the power dependency of the electron density of Ar and helium microplasma in pressure 2kPa.
[Drawing 4] It is drawing which illustrated change of the detection luminescence reinforcement of the pulse injection Ar.
[Drawing 5] It is the microphotography which illustrated the flat-surface configuration of a micro nebulizer.
[Drawing 6] It is the schematic diagram having shown the configuration for actuation of the example of drawing 5 .
[Drawing 7] It is drawing which illustrated an electrical potential difference and the relation of the fluorescence intensity of the atomized sample.
[Drawing 8] It is the schematic diagram having shown the example of a configuration of a system chip.

[Translation done.]

Drawing 1

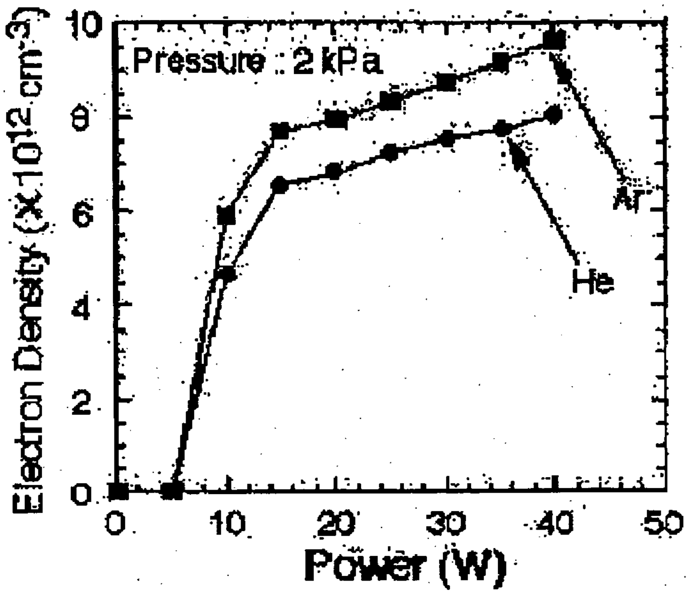


Drawing 2

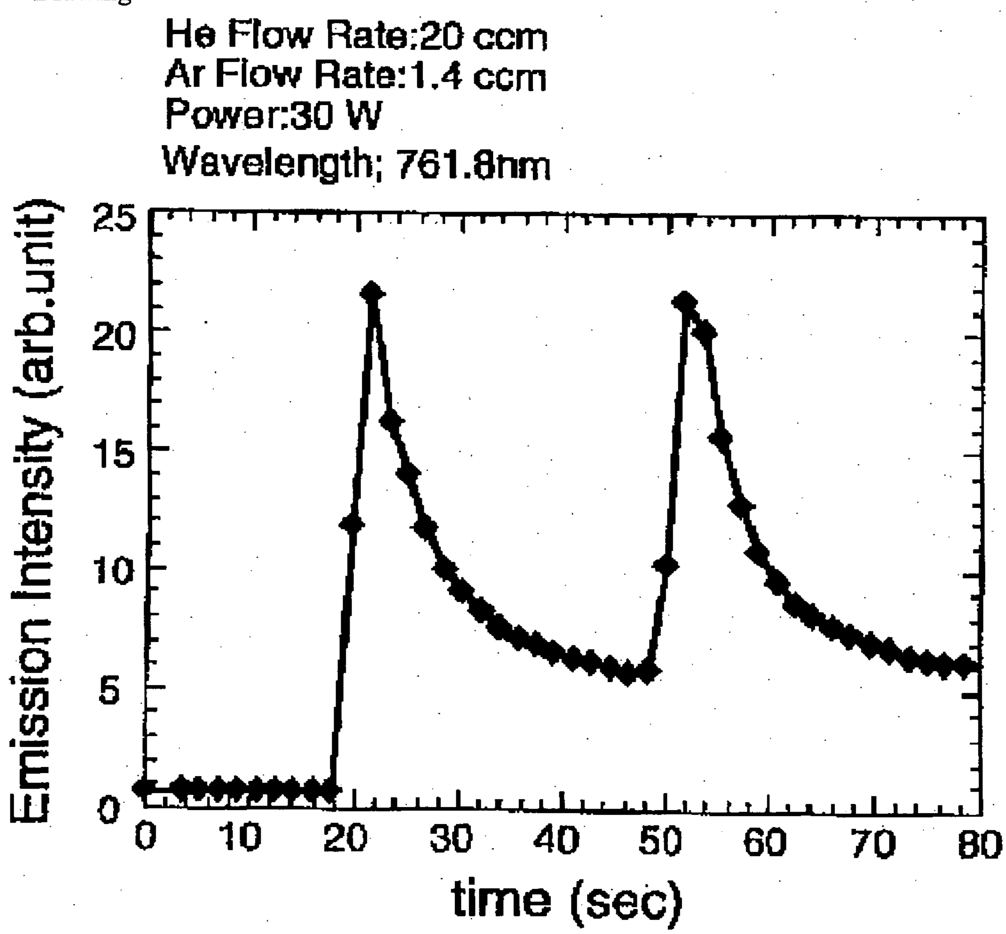


Heプラズマの励起温度

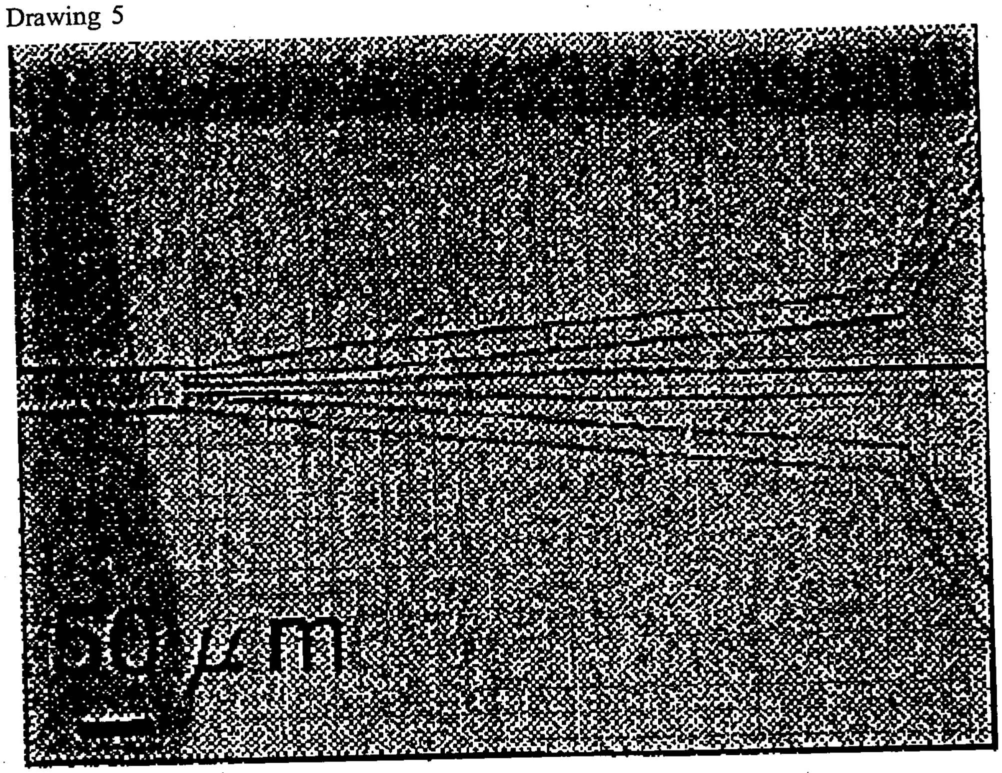
Drawing 3



Drawing 4

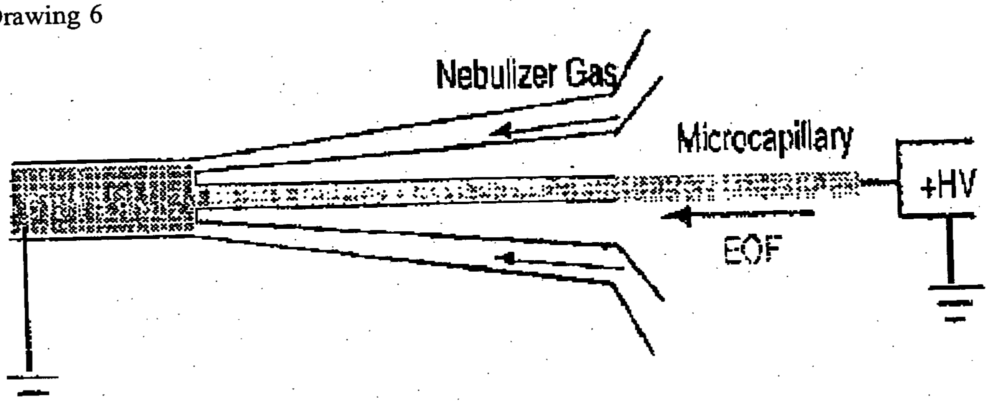


Drawing 5

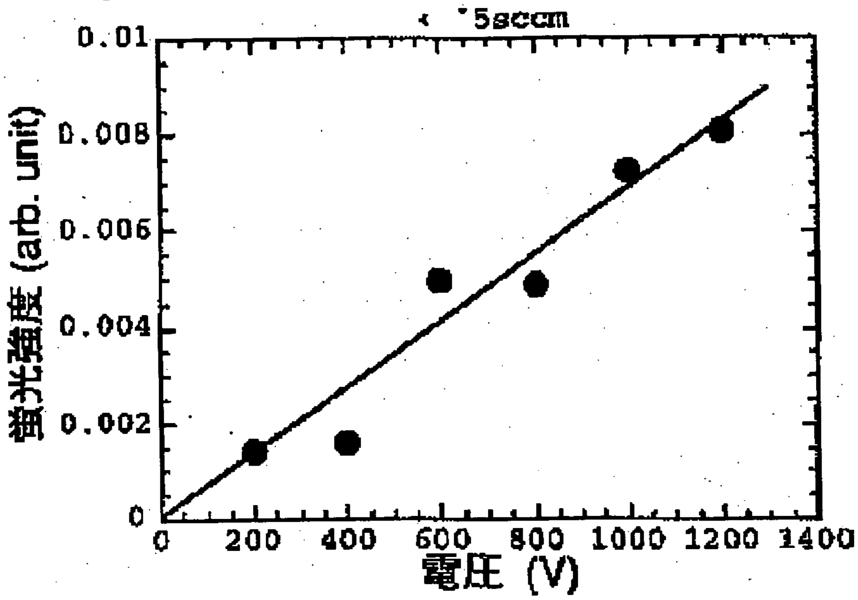


マイクロネブライザー

Drawing 6



Drawing 7



噴霧化された試料の蛍光強度

Drawing 8